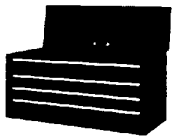
ASOS Trainer's

Tool Box



For a Better Understanding of Automated Surface Observing Systems

National Weather Service, Surface Observation Modernization Office **December 1995**

Wind Gusts for ASOS

A gust is a gust is a gust, right? Who's asking? If you're a pilot, gusts are slightly different from the "highest recorded instantaneous winds" that some of us think of as gusts.

ASOS designers and programmers wanted to reflect the aviation view in the way ASOS measures and reports wind gusts. Because that view is a bit different than other views, people have been slightly confused ever since. That's OK because this Toolbox will clear the air!

The main purpose of this Toolbox is to explain how wind speeds and gusts are calculated and reported. It also will set the record straight on a slight but useful change in the mathematical methods used to compute wind speeds. The developers are using these methods in software changes.

When the NWS first considered ASOS wind and wind gust reporting, the principal concern was what the pilot needed. Earlier research had shown that aircraft respond significantly to sudden increases in wind speed of 5 seconds duration or more. So we decided to measure and report wind speed in 5 second averaged increments. Further, we developed criteria for ASOS to use when gusts, average wind speed, and minimum wind speed, differed from each other by established margins.

Wind Speed Calculations

The process begins by measuring basic wind speeds. The steps that ASOS uses for determining wind speed are to:

- Measure wind speed each second
- Calculate average wind speed for fixed 5 second blocks of time
- Store 2 minutes worth (24) of these 5 second average wind speed values in the computer for further calculations
- Calculate a new, 2 minute average wind speed every 5 seconds using these 5 second values
- Once each minute, store the current 2 minute average wind speeds in the computer for 12 hours.

Wind Gust Calculations

ASOS also is examining these wind speed data to see if it should report a gust. Wind speed calculations use 2 minute time frames, as opposed to gust calculations, which ASOS calculates with data from the most recent 1 minute. ASOS uses threshold levels of wind speed and differences between maximums, minimums, and averages in its calculations for wind gusts.

Every 5 seconds, ASOS reviews all the 5 second wind speed averages for the past minute. The next step is to find the highest and lowest 5-second values in this minute of data. One more value is needed for wind gust evaluations, the most recent 2 minute average wind speed.

ASOS starts the wind gust routine if the 2 minute average wind speed is at least 9 knots. If this condition is met and the highest 5 second value (in the past min-

Old and Corrected Software (s/w) and Human Observer
Average wind: 50 knots, Gust: 70 knots)

actual gust duration	——max peak wind report—— old s/w	corrected s/w	observer
1 sec	54	54	70
2 sec	57.2	58	70
3 sec	59.7	62	70
4 sec	62	66	70
5 sec	63	70	70

ute) exceeds the most recent 2 minute value by at least 5 knots, ASOS records that higher value as a gust. Once ASOS calculates a gust, that value is held in the computer for 10 minutes.

Every 5 seconds, ASOS also looks to see if there has been a "reportable" gust. The system examines the gust calculations of the last 10 minutes. If the current 2 minute average wind speed is greater than 2 knots, and if there has been at least one valid gust calculated, ASOS locates the greatest value of gust and sets the "maximum gust" equal to that value.

Next, ASOS takes the smallest value of 5 second average wind speeds for the past 10 minutes as its minimum wind speed. You will get a "reportable" wind gust if the maximum gust exceeds the 2 minute average wind speed by at least 3 knots or more *and* if the maximum gust exceeds the minimum wind speed by at least 10 knots.

ASOS would then report the basic wind report, generate "G," and list the maximum gust. ASOS reports the value of the maximum gust for 10 minutes unless it is replaced with a higher value in subsequent calculations, in which case the report would retain the new value for 10 minutes.

5 Second Bytes Of Wind

Because ASOS sees the wind in 5 second bites, its wind speeds will be an average across this period. A human observer can report a gust the moment it is measured by wind instruments.

Imagine a case where there was a 5 second long burst of 50 knots against a steady-state wind of 30 knots. You would expect the human observer to report 30G50 (winds 30 knots, gust of 50 knots). If the gust fell in only one second of an ASOS 5 second interval, ASOS would report only a peak wind of 34 knots (30 + 30 + 30 + 30 + 50 = 170 divided by 5 = 34), not enough to report a gust.

The human observer's report would remain 30G50. The average 5 second wind speed would be 38 knots with 2 seconds of 50 knot wind. With 3 seconds, ASOS would report 30G42.

To be "reportable" a gust must be at least 10 knots higher than the smallest 5 second average wind speed in the last 10 minutes.

The report with 4 seconds of the gust would be 30G46. If the gust fell entirely within ASOS's 5 second window, ASOS would report 30G50, the same as the human observer.

There are several things to notice from this example.

One: beyond extremely short periods, there is close agreement between ASOS and what a diligent human might pick up by studying a chart recorder.

Two: there will always be small differences between ASOS and human observations due to the needs of the aviation industry. It is the net effect of winds that last 5 seconds and longer that has a noticeable impact upon planes. That value is what ASOS is designed to report.

Clearing The Air

Developers expected ASOS gust reports to closely match human reports. They felt that ASOS, with its continuous weather watch, would put out more reports than humans and that the ASOS gust amount would be close to or a little less than the human report. Developers thought that large differences would be from gust lengths of just 1 or 2 seconds that are real,

but are of no significance to aviation. But something happened on the way to the factory.

Most wind sensor discussions use the phrase "time or distant constant:" the time (or distance) for a sensor to respond to 63 percent of the wind speed change (e.g., from 30 to 50 knots). For example, if the wind speed suddenly changed from 30 knots to 50 knots, the sensor "time constant" would be the time required for the sensor to change from reporting 30 knots to reporting 42.6 knots (i.e., 63% of the full change in wind speed). The ASOS manufacturer used the equivalent of a 5-second "time constant" in the software rather than the intended 5-second linear average. As a result, ASOS was underestimating even the 5-second wind gusts in the recent versions of software. ASOS now includes the intended mathematical procedures. (See table above.)

Wind Gusts In the Real World

The above example is for an ideal case. It does not account for inertia in the wind vane or gust recorder. There are no really comprehensive studies on the throughput from the actual wind gust to the recorder chart. The consensus is that it takes an average of about 3 seconds for the wind vane to "come up to speed." Thus, in the above example, the worst case scenario would be an observer reporting 70 knots to the ASOS 62 knots.

I believe the actual difference would not even be this great. In one study done at the Sterling Research and Development Center, when the 2 minute average winds were 14 knots, the highest 5 second gust from the Belfort averaged 21.3 knots; the highest 1-second gust from the F420 averaged 22.3 knots.

This test was done using 14 one minute samples taken over a 40 minute period. In each minute, we computed the highest 5-second gust and 1-second gusts from the Belfort and F420 respectively.

In the future, we expect ASOS to agree more closely with the human report. If we don't get better agreement and you still see large discrepancies, well—as in the Bing Crosby picture, you could dial "O" for O'Malley, but you could also call me.

References

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Koren, O., 1973: Digital Output Wind Systems for Airport Use. Journal of Applied Meteorology, Vol. 13, 242-248.

Wieringa, J., 1980: Representativeness of Wind Observations at Airports. Bulletin of American Meteorological Society, Vol. 61, No. 9. Pp 962-971.

Questions

1. What is the averaging time for the ASOS speed and direction?
2. What is the averaging time for a peak wind?
3. When is a 5-sec peak wind considered a gust?
4. How long is this gust held?
5. When is this gust reported?

For More Information

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